Acknowledgements

The New Hampshire Volunteer Lake Assessment Program depends on many people in order to function. Without the following participants, VLAP would be at a loss:

The volunteer monitors, who spend countless hours sampling, not to mention the time many of them spend driving to and from the labs. We extend our greatest thanks to them and hope they will continue to be so concerned for the health of New Hampshire's lakes and ponds.

The Commissioner of the Department of Environmental Services, Bob Varney, who has supported the program for years. We hope to have his cooperation for years to come.

All of the Biology Section interns and staff, who work relentlessly throughout each summer analyzing samples, participating in field work, giving technical assistance to VLAP, while keeping up with their own responsibilities.

The staff, volunteers, and interns of the Lake Sunapee Protective Association, Colby-Sawyer College, and the Sunapee Satellite Laboratory in New London, and new for 2000, at the Franklin Pierce College Laboratory in Rindge. Both labs work very hard to analyze samples and investigate water quality violations in their respective areas. They also take away the burden from volunteers of driving long distances to Concord, which we know is greatly appreciated by the volunteers in those regions.

DES Laboratory Services, who handle a constant influx of samples from VLAP, yet continue to deliver results quickly to the volunteers.

Special thanks to Paul and Dottie Provost of the Suncook Ponds in Barnstead, who appear on the cover of this year's report.

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Introduction

As the years pass us by we find more people who show great concern for the waterbodies of New Hampshire. The New Hampshire Volunteer Lake Assessment Program (NHVLAP) is pleased to welcome the following lakes and ponds to our program: Island Pond, Washington; the Manchester Urban Ponds Restoration Project ponds, including Dorrs Pond, Maxwell Pond, McQuesten Pond, Nutts Pond, Pine Island Pond, and Stevens Pond; Melendy Pond and Lake Potanipo, Brookline; Mine Falls Pond, Nashua; Pleasant Pond, Francestown; Reservoir Pond, Lyme; Robinson Pond, Hudson; and Shellcamp Pond, Gilmanton. We hope that you will continue your efforts in the years to come. New Hampshire is very lucky to have such dedicated volunteer lake monitors who faithfully sample their lakes each year, and for that we thank you all.

NHVLAP has grown continuously since 1995, with 131 lakes sampled this year including 143 in-lake stations. Unfortunately, this year was interrupted by some changes in personnel (we miss Stephanie dearly!) and some lakes were not sampled for one reason or another. We are confident that many of these lakes will return to the program in 2001.

Once again, Sara Sumner was the VLAP intern for the summer; her knowledge and experience were indispensable in helping to keep the interim coordinator's sanity in check! Without her help, this year would have been even more hectic than necessary. Sara is completing her final year at the University of New Hampshire as a Biology major, and continued to work part-time to finish these reports despite her busy schedule. Thank you very much for your dedication, Sara! We would also like to thank Lisa (Dame) Garofalo for her countless hours of identifying plankton, which is not an easy task when there are more than 140 samples to examine! Lisa was married in November and took a job with the Stoneyfield Farms yogurt company. Thanks also to Keira Wonkka who helped with creating graphs. She recently took a job with the City of Nashua. We wish them both the best of luck

The Franklin Pierce College (FPC) Satellite Laboratory completed its first successful summer analyzing samples from the VLAP lakes in the southwestern region of New Hampshire. We wish to extend our congratulations to Michele Hood and her interns, Jonathan Curina and Jennifer Sackett, for their deliberation throughout the summer. As Michele told us recently, without the interns the lab would not have been successful.Many of the volunteers in that area expressed their appreciation for the new lab. The NHDES fully supports the water quality lab at FPC and is confident the analyses conducted at the lab will provide monitors with quality data equal to that at the State labs.

Meet our friend, the Secchiman! This is the new logo for the Volunteer Lake Assessment Program. You will find him on our improved Field Data sheets, the clipboards, and on the new Field Manual.

The Field Manuals were created this winter by one of our interns, Keira Wonkka, with editing and other support from several of the biologists. The manual is to help you when you're sampling out on the lake and serves as an extra reminder for which bottles to use. Use of the manual does not exempt you from having a visit by the VLAP Coordinator. The annual visit is still an integral part of the sampling season, so we can keep up to date on your lake quality by meeting person to person and conducting tests that you don't normally perform on your own. The manual is simply a tool to remind you of sampling techniques.

The 1999 Secchi Dip-In was again a success. Those of you with internet access might want to check the official Secchi Dip-In website at http://dipin.kent.edu for the complete 1999 results. The 2000 results have yet to be posted, but we are certain that New Hampshire will once again rank among the highest average clarities in the nation. The 1999 results show New Hampshire a close third to Maine (second) and Vermont (first) for the New England states, with an average clarity of 4.52 meters. A summary report was not sent to the NHDES for the complete 1999 results; we took this information from the website listed above. We know of several lakes in New Hampshire with clarity readings much higher than 4.5 meters, and we hope they will participate in the 2001 Secchi Dip-In to help increase the state average!

As many of you are aware, VLAP has been without an official coordinator since Stephanie left in May. Sara and Alicia (Hilton) Carlson took on the responsibility of managing the program throughout the summer, with Jody Connor's help of course. At this time, we are in the process of finding a new Coordinator for VLAP. An advertisement was placed in a local newspaper and as a result we received a number of applications. Hopefully a new coordinator will be starting in February, but almost definitely by the spring. We're sure you are all ready to meet the new person when he or she arrives.

Make sure to call to set a date for our annual visit to your lake sometime in the spring. We look forward to seeing you all out on the water next season!

Sincerely,

How to Interpret Graphs and Tables

Graphs

Observation: sample or data point

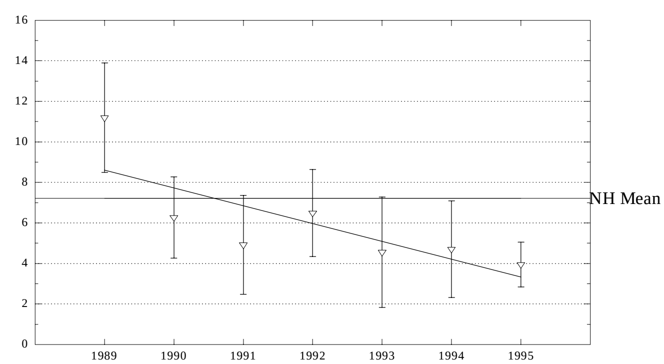
There are two types of graphs in Appendix A of this report, a line graph and bar graph. Each graph conveys much more to the reader than a table or verbal description, so it is important to be able to interpret it correctly. It must be stressed that a lower number of **observations** causes a corresponding decline in the reliability of the information (the more data the better!).

<u>Line Graph</u>

Mean: average

The line graph summarizes sampling results for the years you have collected data (see sample line graph below). The graph shows the **mean** for a given year as an up-turned or down-turned triangle. The triangle points in the direction of more desirable values. For example, chlorophyll-a and total phosphorus have downward triangles (▼), indicating lower values are better, while transparency has upward triangles (▲), signifying higher values are more desirable.

Line Graph Depicting Historical Data



Standard deviation: a statistic measuring the spread of the data around the mean

Range: difference between the high and low values

A measure of the spread of the data around the mean, or **standard deviation**, is shown as the vertical lines extending up and down from the mean. Standard deviation is similar to **range** except standard deviation is a more exact measure of variation. In this case, the lines indicating standard deviation on your graphs illustrate the amount of variation in the results for a particular test for all the times you sampled in that year. For example, if all the chlorophyll readings came back with similar results each time you sampled this year, then the amount of deviation from the average is small. If there was a wide range of chlorophyll concentrations in the lake, then the deviation is large.

Regression Line: a statistical tool used to predict trends in data

Trends in the yearly data can be discerned by looking at the **regression line** and noting its direction and degree of slant (see example next page). If the line is slanted downward like this "\", it indicates an improving trend in chlorophyll-a and total phosphorus but a declining trend in transparency values. If the line is sloped the opposite way (like this "/"), it depicts a worsening trend in chlorophyll-a and phosphorus, but an improving trend in transparency values. The steeper the regression line's slope the stronger the trend. A horizontal regression line (–) indicates the parameter presented is stable, neither improving nor worsening over time.

Caution is warranted when drawing absolute conclusions from yearly data if the lake data set is small. Don't panic if the line graph shows a parameter worsening — check your raw data first. Look for years with one extremely high or low sampling point; this could skew the trend line. Remember, you need four to five years of data before trends become apparent, and ten years before they are considered statistically significant.

The last element in the line graph is a line representing the New Hampshire mean for that particular parameter . Your data can be compared to this value. For a complete summary of water quality test averages in New Hampshire, please turn to page 7.

<u>Bar Graph</u>

The second type of graph found in this report is the bar graph. It represents this year's monthly data for a given parameter. When more than one sampling event occurred in a month, the plotted value will represent **only one result**. Please check your raw data reports to find all of the results. The bar graph emphasizes individual values for comparison rather than overall trends and allows easy data comparisons within one sampling season.

Tables

Tables in Appendix B summarize data collected during 2000 and previous years. Maximum, minimum, and mean values are given for each station by sampling year for most tests, where applicable.

Lake Maps

Bathymetry: the topography of the lake's bottom; depicts lake depths

Maps in Appendix C show the **bathymetry** of your lake. The "X" denotes the deepest spot in your lake, where most of the in-lake sampling is done. Tributary names for major inlets and outlets are labelled on the map, and should be referred to when labelling sample bottles and studying the data in Appendix B. If the map of your lake is not complete, please make any necessary changes and return the map to us so we can create a new map for your use.

Interpreting Data

Watershed: land draining to a particular water body; often described as a funnel

Fertility: capacity to sustain plant growth

Biological Production: total amount or weight of living plants and animals

Limiting nutrient: nutrient that in small increases can cause larger changes in biological production

Oligotrophic: low biological production and nutrients; highest lake classification

Eutrophic: high biological production, nutrient rich; lowest lake classification

Impervious: impenetrable

Epilimnetic: upper water layer

Hypolimnetic: lower water layer

Anoxia: no oxygen present

Like all of us, lakes age over time. Lake aging is the natural process by which a lake fills in over geologic time. They fill in with erosional materials carried in by the tributary streams, with materials deposited directly through the air, and with materials produced in the lake itself. From the time that a lake is created, the aging or filling in process begins. Although many New Hampshire lakes have the same chronological age, they change and fill at different rates because of differences in runoff and **watershed** characteristics. Lakes can fill in more quickly than natural due to human impacts. Eutrophication (or lake "aging") is the process of increased nutrient input to a lake exceeding the natural supply. The **fertility** of the watershed, which is dependent upon land use and geology, determines the rate of lake aging. Increased lake fertilization results in an increase in **biological production**.

The key chemical in the eutrophication process is the nutrient phosphorus. Phosphorus is the **limiting nutrient** in New Hampshire lakes; the greater the phosphorus concentration in a lake, the greater the biological production. Biological production can be measured in terms of plant growth, algal growth, decreased transparency, and an overall decrease in lake quality.

It is very important to understand the meaning of biological production when referring to lakes. We often think of biological production as something good. For example, a productive garden yields an abundance of vegetables. But, when speaking about lake productivity, usually the low biological production associated with a clear, **oligotrophic** lake is the ideal condition. Fisherman, on the other hand, may prefer a productive lake, especially if they are fishing for war water species, like bass. Warm water species thrive in productive lakes because of the abundance of food and presence of plants used for hiding. Excessive weed growth and algae blooms are present in a *highly* productive, **eutrophic** lake.

When eutrophication is caused by human activity it is termed **cultural eutrophication**. This accelerated aging results from watershed activities such as fertilizing, converting forest or pasture to cropland, and creating **impervious** areas such as rooftops, parking lots, and driveways. Studies in New Hampshire have shown that phosphorus exports from agricultural lands is at least 5 times greater than from forested lands, and in urban areas may be more than 10 times greater. Other contributers to cultural eutrophication include faulty septic systems, bathing in or near the lake, erosion into the lake, dumping or burning leaves in or near a lake, and feeding ducks.

As you interpret the data on the following pages, pay close attention to the trends. Look for increases or decreases in the **epilimnetic** and **hypolimnetic** phosphorus. If you observe an increase in hypolimnetic phosphorus as the summer progresses, a process called *internal phosphorus loading* is occurring. This means phosphorus that was tied up in the lake floor sediments is now able to enter the water column. **Anoxia** accelerates this process.

What if there was an increase in epilimnetic phosphorus? As you look at the data from the inlets notice if this year's data show an increase in phosphorus from a particular inlet. If the increase is signficant the new source of phosphorus should be investigated.

Transparency: water clarity

Chlorophyll-a: green pigment found in plants; used to measure the amount of algae in a lake

Correlations between **transparency** and **chlorophyll-a** are important. If the chlorophyll-a increased and the Secchi disk transparency decreased increased algae populations are affecting the water clarity. If the chlorophyll-a has not increased, but the transparency has undergone a decline (for example, a reading from 4 meters down to 2 meters) the reduced transparency could be attributed to turbidity caused by stream inputs, motorboat activity, shoreline construction, or disturbances of bottom sediments.

Non-point pollution: pollution originating in the watershed, often entering the water body via surface runoff or groundwater

Conductivity, acid neutralizing capacity (ANC), and pH should also be examined. The lower the ANC value for your lake the more vulnerable it is to acid precipitation. Conductivity is a good indicator of disturbance or **non-point sources** of pollution. A marked increase or decrease in any parameter should be investigated.

Epilimnion: upper water layer

Metalimnion: middle water layer (a.k.a. thermocline)

Hypolimnion: bottom water layer

Tributary: stream, inlet

All of the data might seem overwhelming to you at the start. First, take a look at the in-lake data. The tables in Appendix B will list in-lake data either as **Epilimnion, Metalimnion,** or **Hypolimnion.** The number of layers formed in a given year is dependent upon lake depth and seasonal temperatures; if your lake has only two layers only epilimnetic and hypolimnetic data will be displayed, or epilimnetic data only if the lake is too shallow to form layers. Follow the trends within each layer and note any changes for each parameter.

Then examine the **tributary** data. Look at each inlet, one at a time. Some will reflect good conditions (low total phosphorus, low conductivity, and pH between 6.0 and 7.0). Others might reflect poor tributary quality, sending off a warning light (high total phosphorus, high conductivity, or low pH). List the possible problems you identified from your data and prioritize them according to your association's goals. Keep in mind that weather patterns during the sampling season will strongly affect the quality of the lake. Heavy rainfall or large amounts of snow melt can result in nutrient-rich and sediment-laden runoff to the lake. On the other hand, a dry season will have an absence of such runoff, potentially resulting in greater water clarity and less nutrients to feed algae and plant growth. *Weather patterns should be carefully considered when assessing lake changes from year to year, or even within a sampling season.*

Biological: living plants or organisms

Physical: parameters related to the chemistry of water

To provide an understanding of how your water body compares to other New Hampshire lakes the following table summarizes key **biological** and **physical** parameters for all the state's lakes surveyed since 1976.

Summary Statistics for New Hampshire Lakes and Ponds

Parameter	Number*	Min.	Max.	Mean	Median
pH (units)	736	4.3	9.6	**6.5	6.6
ANC (mg/L)	737	-3	77	6.4	4.8
Conductivity (µmhos/cm)	727	13.1	629	56.8	37.2
Turbidity (NTU)	272	<1	22	------	1.0
Total Phosphorus (µg/L)	729	<1	121	------	12
Chlorophyll-a	732	0.19	143.8	7.4	4.51
Secchi Disk (m)	628	0.25	13.0	3.7	3.3

* Number= the number of lakes sampled
** true mean pH

Finally, refer to the Observations and Recommendations section of this report, which discusses the basic trend data and also lists some suggestions for future sampling. Then, formulate a plan and call us for help. Once you know where your concerns lie, we will work with you to modify your current sampling program to address these goals. You may also be eligible to apply for Local Initiative Grants through DES to help fund watershed improvement and education efforts at your lake. Don't procrastinate too long; summer will be here before you know it!

Monitoring Parameters

Biological Parameters

Algal Abundance

Algae are photosynthetic plants that contain chlorophyll but do not have true roots, stems, or leaves (a.k.a. "phytoplankton"). They do, however, grow in many forms such as aggregates of cells (colonies), in strands (filaments), or as microscopic single cells.

Photosynthesis: producing carbohydrates with the aid of sunlight

Food chain: arrangement of organisms in a community according to the order of predation

Oxygenated: holding oxygen in solution

Regardless of their form, these primitive plants carry out **photosynthesis** and accomplish two very important roles in the process. First, inorganic material is converted to organic matter. These tiny plants then form the base of a lake **food chain**. Microscopic animals (zooplankton) graze upon algae like cows graze in a field. Fish also feed on the algae along with other organisms. Second, the water is **oxygenated**, aiding the chemical balance and biological health of the lake system.

Algae require light, nutrients, and certain temperatures to thrive. All of these factors are constantly changing in a lake from day to day, season to season, and year to year. Therefore, algae populations and the abundance of individual species of algae naturally fluctuate with weather changes or changes in water quality.

Chlorophyll-a: a green pigment found in algae

Oligotrophic: low biological production

Eutrophic: high biological production; nutrient rich

NHVLAP uses the measure of **chlorophyll-a** as an indicator of the algae abundance. Because algae is a plant and contains the green pigment chlorophyll, the concentration of chlorophyll found in the water gives us an estimation of the concentration of algae. If the chlorophyll-a concentration increases, this indicates an increase in the algal population. Generally, a chlorophyll-a concentration of less than 4 mg/m^3 indicates water quality conditions that are representative of **oligotrophic** lakes, while a chlorophyll-a concentration greater than 15 mg/m^3 indicates **eutrophic** conditions. Chlorophyll concentrations greater than 10 mg/m^3 generally indicate an algae bloom, or the excessive reproduction of algae.

Mean: average

The **mean** chlorophyll-a for New Hampshire lakes is 7.4 mg/m^3. Figure 1 (App.A) and Table 1 (App.B) present the mean chlorophyll-a concentrations for each year of participation in NHVLAP. Table 1 also presents the minimum and maximum values recorded for the same years.

Chlorophyll-a (µg/L)	
0-5	Good
5.1-15	More than desirable
>15	Nuisance amounts

Phytoplankton

Phytoplankton: microscopic algae floating in the water column

Plankton net: fine mesh net used to collect microscopic plants and animals

The type of **phytoplankton** present in a lake can be used as an indicator of general lake quality. The most direct way to obtain phytoplankton information involves collection of a sample with a **plankton net**, measurement of the quantity of phytoplankton contained in the sample, and identification of the species present using a microscope. An abundance of blue-green algae, such as *Anabaena, Aphanizomenon, Oscillatoria,* or *Microcystis* may indicate excessive phosphorus concentration or that the lake ecology is out of balance. On the other hand, diatoms such as *Asterionella, Melosira,* and *Tabellaria* or golden-brown algae such as *Dinobryon* or *Chrysosphaerella* are typical phytoplankton of New Hampshire's less productive lakes.

Succession: the decline of dominant species of algae over a period of time as another species increases and becomes dominant

Phytoplankton populations undergo a natural **succession** during the growing season. Many factors influence this succession: amount of light, availability of nutrients, temperature of the water, and the amount of grazing occurring from zooplankton. As shown in the diagram on page 10, it is natural for diatoms to be the dominant species in the spring, then green algae in the early summer, followed by dominating blue-green algae in mid to late summer. The plankton samples from your lake will show different dominant species, depending on when the samples were taken. Phytoplankton are identified in Table 2 in Appendix B. Phytoplankton groups and species are listed below.

Phytoplankton Groups and Species for New Hampshire Lakes and Ponds

Greens

Actinastrum	*Eudorina*	*Pandorina*	*Spirogyra*
Arthrodesmus	*Kirchneriella*	*Pediastrum*	*Staurastrum*
Dictyosphaerium	*Micractinium*	*Scenedesmus*	*Stigeoclonium*
Elakotothrix	*Mougeotia*	*Sphaerocystis*	*Ulothrix*

Diatoms

Asterionella	*Melosira*	*Rhizosolenia*	*Synedra*
Cyclotella	*Pleurosigma*	*Surirella*	*Tabellaria*
Fragilaria			

Dinoflagellates

Ceratium	*Peridinium*	*Gymnodinium*	

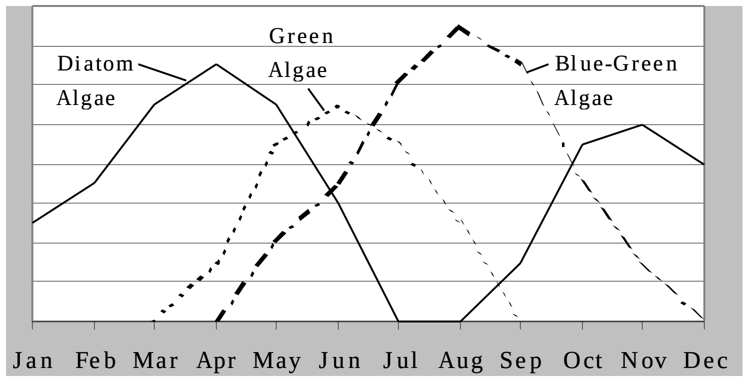
Blue-Greens

Anabaena	*Chroococcus*	*Gloeotrichia*	*Microcystis*
Aphanizomenon	*Coelosphaerium*	*Lyngbya*	*Oscillatoria*
Aphanocapsa			

Golden-Browns

Chrysosphaerella	*Mallomonas*	*Synura*	*Uroglenopsis*
Dinobryon			

A Typical Seasonal Succession of Lake Algae



Secchi Disk Transparency

Color: apparent water color caused by dissolved organic compounds and suspended materials

The Secchi disk is a 20 centimeter disk with alternating black and white quadrants. It has been used since the mid-1800s to measure the transparency of water. The Secchi disk is named after the Italian professor P.A. Secchi whose early studies established the experimental procedures for using the disk. The disk is used to measure the depth that a person can see into the water. Transparency, a measure of the water clarity, is affected by the amount of algae, **color**, and particulate matter within a lake. In general, a transparency greater than 4 meters indicates oligotrophic conditions, while a transparency of less than 2 meters is indicative of eutrophic conditions.

The mean transparency for New Hampshire lakes is 3.7 meters (one meter equals 3 feet, 4 inches). Figure 2 in Appendix A presents a comparison of the transparency values for each of the VLAP monitoring years, while Table 3 of Appendix B shows minimum, maximum, and mean values for all years of participation.

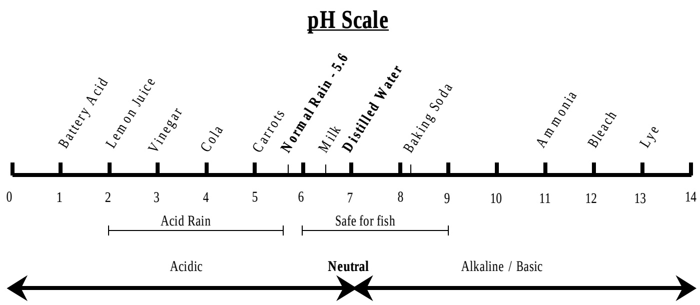
**Water Clarity (Transparency)
Ranges for Lakes and Ponds**

Category	Water Clarity (m)
Poor	<2
Good	2-4.5
Exceptional	>4.5

Chemical Parameters

pH

pH is measured on a logarithmic scale of 0 to 14. The lower the pH the more acidic the solution, due to higher concentrations of hydrogen ions. Acid rain typically has a pH of 3.5 to 5.5 due to pollutants added from the air. In contrast, the median pH for New Hampshire lakes is 6.6.



Lake pH is important to the survival and reproduction of fish and other aquatic life. A pH below 5.5 severely limits the growth and reproduction of fish. A pH between 6.5 and 7.0 is ideal.

Thermally stratified: layered by temperature

Bacteria: tiny organisms that break down dead matter

Phytoplankton: microscopic algae floating in the water column

Many lakes exhibit lower pH values in the deeper waters than nearer the surface. This effect is greatest in the bottom waters of a **thermally stratified** lake. Decomposition carried out by **bacteria** in the lake bottom causes the pH to drop, while photosynthesis by **phytoplankton** in the upper layers can cause the pH to increase. Tannic and humic acids released to the water by decaying plants can create more acidic waters in areas influenced by wetlands.

Table 4 in Appendix B presents the in-lake and tributary true mean pH data.

pH Ranges for New Hampshire Lakes and Ponds

Category	pH (units)
Acidified	<5
Critical	5.0-5.4
Endangered	5.5-6.0
Satisfactory	6.1-8.0

Acid Neutralizing Capacity

Buffering capacity or Acid Neutralizing Capacity (ANC) describes the ability of a solution to resist changes in pH by neutralizing the acidic input to the lake. The higher the ANC the greater the ability of the water to neutralize acids. Low ANC lakes are not well buffered. These lakes are often adversely affected by acidic inputs.

Historically, New Hampshire has had naturally low ANC waters because of the prevalence of granite bedrock. (Granite does not contain elements that have buffering capacity, like limestone.) The average ANC for New Hampshire lakes is 6.4 mg/L. This relatively low value makes them vulnerable to the effects of acid precipitation. Table 5 in Appendix B presents the mean epilimnetic ANC for each year your association has been involved in this program.

Acid Neutralizing Capacity Ranges for New Hampshire Lakes and Ponds

Category	ANC (mg/L)
Acidified	<0
Critical	>0-2
Endangered	>2-5
Highly Sensitive	>5-10
Sensitive	>10-20
Not Sensitive	>20

Conductivity

Ionic paricle(s): an atom or group of atoms carrying an electrical charge

Conductivity is the numerical expression of the ability of water to carry an electrical current. It is determined primarily by the number of **ionic particles** present. The soft waters of New Hampshire have traditionally had low conductivity values. High conductivity may indicate pollution from such sources as road salting, faulty septic systems, or urban/agricultural runoff.

Erosion: soil materials worn away by the action of water or wind

Specific categories of good and bad levels cannot be constructed for conductivity, because variations in watershed geology can result in natural fluctuations in conductivity. However, values in New Hampshire lakes exceeding 100 generally indicate cultural (man-made) sources of ions. The conductivity should remain fairly constant for a given lake throughout the year. Any major changes over a short period of time may indicate **erosion** resulting from heavy rain or a large flush of runoff from a problem site. Conductivity less than 50 umhos/cm is typical of oligotrophic lakes. Conductivity greater than 100 umhos/cm is more typical of lakes with greater human impacts.

The mean conductivity for New Hampshire lakes is 56.8 umhos/cm. Table 6 in Appendix B presents mean conductivity values for tributaries and in-lake data.

Phosphorus

Algal blooms: over-population of algae

Phosphorus is the most important water quality parameter measured in our lakes. It is this nutrient that limits the algae's ability to grow and reproduce. Limited phosphorus in a lake will result in limited, natural algae concentrations. Increased phosphorus levels encourage excessive plant growth and **algal blooms.** Phosphorus occurs in many forms in a lake and is absorbed by algae, becoming part of a living cell. When the algae cell dies the phosphorus is still organically bound, even as the dead cells settle to the lake bottom.

Phosphorus sources around a lake include septic systems, animal waste, lawn fertilizer, road and construction erosion, and natural wetlands.

An in-lake epilimnetic phosphorus concentration of less than 10ug/L indicates oligotrophic conditions, while a concentration greater than 20 ug/L in the upper layer is indicative of eutrophic conditions. The **median** phosphorus concentration in the upper water layer of New Hampshire lakes is 11 ug/L.

Median: a value in an ordered set of values below and above which there is an equal number of values

Figure 3 in Appendix A shows the epilimnetic and hypolimnetic total phosphorus values for 2000 and historical data. Table 8 in Appendix B presents mean total phosphorus data for in-lake and tributary data.

Total Phosphorus Ranges for New Hampshire Lakes and Ponds (Epilimnetic)

Category	TP (ug/L)
Low (good)	1-10
Average	11-20
High	21-40
Excessive	>40

Dissolved Oxygen and Temperature

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, species intolerant to this situation, such as trout, will be forced to move or may not survive.

Temperature is also a factor in the dissolved oxygen concentration. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring, and fall than in summer.

Thermal stratification: layering by temperature

ppm: parts per million; equal to mg/L

Internal loading: addition of phosphorus to the hypolimnion from the lake sediments due to low oxygen conditions

Thermocline: barrier between warm surface layer and cold deep layer

At least once during this summer, a DES biologist measured dissolved oxygen and temperature at set intervals from the bottom of the lake to the surface. These measurements allow us to determine the extent of **thermal stratification** as well as the oxygen content of the lake. Many of the more productive lakes experience a drop in dissolved oxygen in the deeper waters as the summer progresses. Bacteria in the lake sediments decompose the dead organic matter that settles out, a process that depletes oxygen in the bottom waters. Since more productive lakes tend to have organic-rich sediments there will be greater decomposition on the bottom of such lakes, potentially creating a severe dissolved oxygen deficit (less than 1 **ppm**). This low oxygen condition can then trigger phosphorus that is normally bound to the sediment to be released into the water (**internal loading**).

Dissolved oxygen percent saturation shows the percentage of oxygen that is dissolved in the water at a particular depth. Typically, the deeper the reading the lower the percent saturation. A high reading at or slightly above the **thermocline** may be due to a layer of algae, producing oxygen during photosynthesis. Colder waters are able to hold more dissolved oxygen than warmer waters, and generally, the deeper the water the colder the temperature. As a result, a reading of 9 mg/L of oxygen at the surface will yield a higher percent saturation than a reading of 9 mg/L of oxygen at 25 meters, because of the difference in water temperture. Table 9 in Appendix B illustrates the Dissolved Oxygen/Temperture profile(s) for 2000, and Table 10 shows historical hypolimnetic dissolved oxygen readings.

Turbidity

Turbidity in water is caused by suspended matter, such as clay, silt, and algae that cause light to be scattered and absorbed, not transmittted in straight lines through the water. Secchi disk transparency, and therefore water clarity, is strongly influenced by turbidity. High turbidity readings are often found in water adjacent to construction sites; during rain events unstable soil erodes and causes turbid water downstream. Also, improper sampling techniques (hitting the bottom of the lake with the Kemmerer bottle or stirring up the stream bottom when collecting tributary samples) may also cause high turbidity readings. The New Hampshire median for lake turbidity is 1.0 NTU. Table 11 in Appendix B lists turbidity data for 2000.

Statistical Summary of Turbidity Values for New Hampshire Lakes and Ponds

Category	Value (NTU)
Minimum	<0.1
Maximum	22.0
Median	1.0

Bacteria

Surface waters contain a variety of microorganisms including bacteria, fungi, protozoa, and algae. Most of these occur naturally and have little or no impact on human health. Health risks associated with water contact occur generally when there is contamination from human sources. Warm blooded animals such as ducks, beaver, geese, and pets can also contribute bacteria to surface waters. Contamination arises most commonly from sources of fecal waste such as failing or poorly designed septic systems, leaky sewage pipes, nonpoint source runoff from wildlife habitat areas, or inputs from wastewater treatment plant outflows within a watershed. Swimming beaches with heavy use, shallow swim areas, and/or poor water circulation also have commonly reported bacteria problems. Therefore, water used for swimming should be monitored for indicators of possible human fecal contamination. Contamination is typically short-lived, since bacteria cannot survive long in water; their natural environment is the gut of warm blooded animals.

Specific types of bacteria, called indicators, are the basis of bacteriological monitoring, because their presence tends to indicate fecal contamination.

Pathogens: disease-causing organisms

Indicators estimate the presence and quantity of things that cannot be meaured easily by themselves. We measure these sewage or fecal indicators rather than the **pathogens** themselves to estimate sewage or fecal contamination and, therefore, the possilbe risk of disease associated with using the water.

New Hampshire's surface water bacteriological standard were recently changed. As of September 1991, the indicator organism changed from total coliform to *Escherichia coli* (*E. coli*). The new standards for Class B waters specify that no more than 406 *E. coli*/100 mL, or a geometric mean based on at least 3 samples obtained over a 60 day period be greater than 126 *E. coli*/ 100 mL. Designated beach areas have more stringent standards: 88 *E. coli*/ 100 mL in any one sample, or a geometric mean of three samples over 60 days of 47 *E. coli*/100 mL. Table 12 shows bacteria (*E. coli*) results for 2000.